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XLVI.—*On* Cyclostigma, *a new Genus of Fossil Plants from the Old Red Sandstone of Kiltorcan, co. Kilkenny; and on the General Law of Phyllotaxis in the Natural Orders* Lycopodiaceæ, Equisetaceæ, Filices, *&c.* By the Rev. Samuel Haughton, F.R.S., Professor of Geology in the University of Dublin.

The extremely imperfect condition in which fossil plants are usually found, and the almost total absence of their more important organs, lead us naturally to lay stress on such characters as are found persistent in the fossil condition. Among these, one of the most important, as I believe, is the geometrical law of arrangement of their leaves. A careful examination of this arrangement leads me to conclude that the leaves of Palæozoic fossil plants are arranged according to a different law from that which prevails in the ordinary Exogens and Endogens, and usually described in elementary text-books of botany.

The law of arrangement is very simple, and may be thus expressed:—

"*The leaves, or leaf-scars, are arranged in whorls, so placed that each leaf is directly above or below a leaf of the alternate whorls, and intermediate to the leaves of the adjacent whorls.*"

The development of leaves following this law may be easily conceived by imagining the whorl to ascend spirally on the stem, traversing an angle $\left(\frac{180^\circ}{n}\right)$ between each of its resting-places; n denoting the number of leaves in each whorl. This is the same as supposing *each* leaf to have an independent law of development, of the ordinary kind, expressed by

$$\text{Divergence} = \frac{1}{2n}.$$

The leaves, according to this view, are developed in simultaneous whorls, and cannot be supposed to be produced in succession, as in alternate-leaved plants.

Some of the whorled-leaved Exogens may be reduced to this law, such as the simple case of opposite-leaved plants, which is not reducible to the common law of phyllotaxis, as we cannot suppose the two opposite leaves to be produced in succession; but the great majority of Exogens follow a different law.

According to all writers on botany, the leaves of alternate-leaved Exogens and Endogens are placed upon the stem at angles represented by the fractions

$$\tfrac{1}{2}, \tfrac{1}{3}, \tfrac{2}{5}, \tfrac{3}{8}, \tfrac{5}{13}, \tfrac{8}{21}, \tfrac{13}{34}, \text{\&c.}$$

of an entire circumference.

In opposite-leaved plants, which is the simplest case of whorled structure, we cannot assign any such law of development to the leaves, even by calling to our aid the hypothesis of arrested growth, for the leaves succeed each other at intervals of $\frac{1}{2}$, $\frac{1}{4}$, alternately, and cannot be reduced to the phyllotaxis of alternate leaves. We should therefore, I believe, assign to all whorled plants a law of phyllotaxis of their own, which is very simple, as already stated.

The floral envelopes of almost all Exogens and Endogens follow this law of whorled structure, so much so that any deviation from it is remarked, and considered due to the suppression of a whorl, as in the case of the Primulaceæ. It is therefore evident that there must be some mode of passing from one law to the other, as both occur in the same plant. As it is impossible to reduce the law of whorled-leaved plants to that of the alternate-leaved plants, I have made some attempts in the opposite direction, but have not yet collected sufficient facts to draw any general conclusions. I shall give an example or two.

Many of the Exogens possess a five-leaved whorled arrangement of their floral organs, while the leaves of the stem are arranged alternately at a divergence of $\frac{2}{5}$. This may be deduced from four whorls in the following manner:—Let the alternate whorls be suppressed; if the remaining whorls were converted into a spiral, they would consist of two spires of five leaves each, with an angle of divergence of $\frac{1}{5}$; but if we suppose the alternate leaves suppressed, the two spirals would coalesce and form one, taking two turns round the axis, and containing five leaves, giving an angle of divergence of $\frac{2}{5}$.

If I were at liberty to adopt the Law of Natural Selection, I should say that, no doubt, the plant found it to its advantage to drop these supernumerary leaves, and so became elevated into the condition of an alternate-leaved plant.

In the preceding case, in order to deduce the arrangement of the leaves from that of the flowers, we have supposed the suppression of alternate whorls, and of the alternate leaves of each whorl preserved, making a suppression of 75 per cent. of the leaves. In other cases, the suppression of leaves is only 50 per cent., as in the case of most Endogens whose flowers consist of alternating whorls of three organs. If we suppose, in this case, the suppression of alternate whorls, and a spiral arrangement, the divergence will become $\frac{1}{3}$.

In the case of opposite-leaved plants, the suppression of alternate whorls will give us the *distichous* arrangement, $\frac{1}{2}$, at an expenditure of 50 per cent. of leaves.

In these and many other cases, we can deduce, by the hypothesis of suppression, the alternate-leaved phyllotaxis from the whorled; and it is worthy of remark, and leads me to my more immediate subject, that the whorled arrangement, which is rare (with the exception of opposite-leaved plants) among Exogens and Endogens, was the common arrangement of leaves among the Coal-plants, and, so far as we know, among the plants of the Old Red Sandstone, which forms the base of the Carboniferous rocks.

The Palæozoic trees and plants are referred to natural orders, resembling in many respects our recent Lycopodiaceæ, Equisetaceæ, and Ferns. In all these orders, the whorled phyllotaxis of the kind I have described commonly prevails.

I. Lycopodiaceæ*.

1. *Lycopodium dendroideum* (Herb. Oakes). Canada. Leaves of stem arranged in alternate whorls of 7 leaves in each. Divergence of whorl = $\frac{1}{14}$.

2. *L. densum.* New Zealand. Leaves of stem in alternate whorls of 7 each. Divergence = $\frac{1}{14}$.

3. *L. clavatum.* Massachusetts. Leaves of stem and flower-stalk in alternate whorls of 7 each. Divergence = $\frac{1}{14}$.

4. *L. divaricatum.* Nepaul. Leaves of stem in alternate whorls of 11 each. Divergence = $\frac{1}{22}$. Leaves of flower-stalks in alternate whorls of 8 each. Divergence = $\frac{1}{16}$.

5. *L.* (n. sp.). Caraccas, S. America. Leaves of lower stem in alternate whorls of 7 each. Divergence = $\frac{1}{14}$. Leaves of upper stem in alternate whorls of 2 each (i. e. opposite-leaved). Divergence = $\frac{1}{4}$.

6. *L. volubile.* New Zealand. Leaves of lower stem in alternate whorls of 4 each. Divergence = $\frac{1}{8}$. Leaves of upper stem in alternate whorls of 2 each. Divergence = $\frac{1}{4}$.

* The plants examined by me for the purposes of this paper are those preserved in the Herbarium of Trinity College.

7. *L. Selago*. Canton Ticino. Leaves of stem in alternate whorls of 4 each. Divergence = $\frac{1}{8}$.

8. *L. reflexum*. Pacific. Leaves of stem in alternate whorls of 9 each. Divergence = $\frac{1}{18}$.

This plant has a striking external resemblance to *Lepidodendron minutum* and to some of the smaller Cyclostigmas of Kiltorcan.

9. *L. quadrifasciatum*. Leaves of stem in alternate whorls of 2 each. Divergence = $\frac{1}{4}$.

10. *L. verticillatum*. Mauritius. Leaves of stem in alternate whorls of 7 each. Divergence = $\frac{1}{14}$.

This plant resembles some of the Kiltorcan plants which have been called *Knorria*.

11. *L. gridoïdes*. Mauritius. Leaves of stem in alternate whorls of 2 each. Divergence = $\frac{1}{4}$.

12. *L. flagellarium*. New Zealand, North Island. Leaves of stem in alternate whorls of 2 each. Divergence = $\frac{1}{4}$.

13. *L. varium*. Lord Auckland's Islands. Leaves of stem in alternate whorls of 4 each. Divergence = $\frac{1}{8}$.

14. *L. catharticum*. Peru. Leaves of stem in alternate whorls of 2 each. Divergence = $\frac{1}{4}$.

15. *L.* (n. sp.). Quito. Leaves of stem in alternate whorls of 8 each. Divergence = $\frac{1}{16}$.

This plant bears a close external resemblance, on a smaller scale, to *Lepidodendron dichotomum*.

Sufficient evidence has been adduced to prove that the Lycopodiaceæ follow the geometrical law of alternate whorls. Collecting together the results, we find the following angles of divergence:—

In 6	species	an angle of	$\frac{1}{4}$.
5	,,	,,	$\frac{1}{14}$.
3	,,	,,	$\frac{1}{8}$.
2	,,	,,	$\frac{1}{16}$.
1	,,	,,	$\frac{1}{18}$.
1	,,	,,	$\frac{1}{22}$.

These numbers correspond with whorls consisting of 2, 4, 8 leaves, being powers of 2, and whorls containing prime numbers of leaves 7, 9, 11.

The *prime* whorls could not give rise to any of the known phyllotaxes of alternate-leaved plants; but the whorls of powers of 2 may do so as follows:—

(1). The whorl of 2, by suppression of the alternate whorls, gives the phyllotaxis = $\frac{1}{2}$. Reduction of 50 per cent. of leaves.

(2). The whorl of 4, by suppression of the alternate whorls and alternate leaves, gives the phyllotaxis = $\frac{1}{2}$. Reduction of 75 per cent. of leaves.

(3). The whorl of 8 leaves, by suppression of the alternate whorls, and of $\frac{2}{3}$ of the remaining leaves, might give rise to the well-known phyllotaxis = $\frac{3}{8}$. Reduction of 83 per cent. of leaves.

It may be supposed by some that the plants, having got rid of superfluous leaves, expended the surplus vitality thus acquired in perfecting their flowers and fruit into higher types; but if this be so, how are we to account for the retention of the whorled structure in the floral organs?

The calyx, corolla, and stamens of Exogens and Endogens obey the law of alternate whorls, when definite; but the pistil in many cases progresses into the spiral type. When the carpels are few and definite, they form a whorl; but where indefinite, as in *Ranunculus, Myosurus,* and *Magnolia,* and such like cases, they are as strictly spiral as leaves. Also, in monstrous roses, we have the pistils returning to the condition of leaves,—green, cut, and spirally arranged.

II. Equisetaceæ.

1. *Equisetum alpestre.* Norway (North). Sheath whorls alternate, 4 in each. Branch whorls 7 in each.

2. *E.* (sp.). Ceylon. Sheath whorls alternate, 16 in each. Branch whorls (irregular), 1 in each. Fruit whorls 10–13 in number, alternate hexagons, 10 in each.

3. *E.* (sp.). Nilghiri Hills, S. India. Sheath whorls alternate, 24 in each. Ditto (upper part of plant) 8 in each. Branch whorls (irregular), 1–3 in each. Fruit whorls 10–12 in number, alternate hexagons, 8 in each.

4. *E. elongatum.* Mount Sarial, Georgia. Sheath whorls alternate, 12–14 in each. Fruit whorls 10 in each. Branch whorls 8 in each.

5. *E.* (sp.). Western Texas and New Mexico. Sheath whorls alternate, 24–30 in each.

6. *E. arvense.* Providence, Rhode Island; and Berne. Sheath whorls alternate, 8 in each. Fruit whorls (12–14 in number) alternate, 8 in each. Branch whorls 8 in each.

7. *E. limosum.* Providence, Rhode Island. Sheath whorls alternate, 14–16 in each. Fruit whorls (12 in number) alternate, 16 in each. Branch whorls 0–10 in each.

8. *E.* (sp.). Ipswich, Massachusetts. Sheath whorls alternate, 12 in each. Fruit whorls 12 in each.

9. *E. sylvaticum.* Ipswich, Massachusetts. Sheath whorls alternate, 12 in each. Branch whorls 10 in each.

10. *E. hyemale*. Mexico and Berne. Sheath whorls alternate, 16 in each. Fruit whorls (9 in number) alternate, 8 in each.

11. *E.* (sp.). California. Sheath whorls alternate, 16–24 in each. Fruit whorls (28–29 in number) alternate, 16 in each. Branch whorls 16–20 in each.

12. *E. debile*. E. Indies. Sheath whorls alternate, 24 in each. Branch whorls 4 in each.

13. *E. giganteum*. Peru. Lower sheath whorls alternate, 24 in each. Upper ditto alternate, 12 in each. Lower branch whorls 24 in each; upper ditto, 12 in each.

14. *E. fluviatile*. Berne and Limerick. Sheath whorls alternate, 24–30 in each. Fruit whorls 16–20 in each. Branch whorls 20–30 in each.

15. *E. arvense*. British. Branch whorls of barren stems 13 in each. Sheath whorls of fruitful stems 8 in each. Fruit whorls alternate (14 in number), 8 in each.

From an examination of the preceding, I conclude (rejecting the branch whorls, which are generally deficient in number) that the number of leaves in the alternate whorls of the Equisetaceæ are represented by the arithmetical series whose first term is 4, and common difference also 4:—

4?, 8, 12, 16, 20?, 24, 28?, 32?,

the terms to which I have appended queries being more doubtful than the others.

I at first thought there were two series—

4, 8, 16, 32,

and 12, 24,

formed by simple dichotomy; but the case of the Nilghiri Hill *Equisetum* proves the occurrence of 8 and 24 on the same plant, and the Californian *Equisetum* shows the concurrence of 16 and 24,—thus proving that there is only one series of numbers, and that a series in arithmetical progression. The whorl of 8 leaves, which, next to that of 16, is the most common, is the only one related to the phyllotaxis of alternate-leaved plants.

III. Filices.

The rhizome or root-stock of the Ferns presents many irregularities, the leaves being sometimes apparently alternate, but often truly arranged in whorls. The genus *Cyathea*, or Tree-fern, from the Feejee Islands, is that which presents most analogy to the fossil plants of the Old Red Sandstone, so far as the leaf-scars are concerned. These scars are arranged in quincunx, and are ovoid or elliptical-lanceolate, according to the slowness or rapidity of the growth of the stem. Of the other Ferns I have examined, the *Oleandra* presents the most marked examples of the whorled structure.

1. *Cyathea* (sp.). Feejee Islands. Root-stock of specimen examined 4–5 feet long, containing 35 rows of whorls of 3 leaves each, placed alternately. The scars of this plant present the most striking resemblance to many of those found in *Lepidodendra.* The angle of divergence of the whorl is $\frac{1}{6}$.

By the suppression of alternate whorls, it would give the angle $\frac{1}{3}$, alternate-leaved, and, by the additional suppression of one-third of the remaining leaves, it would give the angle $\frac{2}{5}$: in this latter case the reduction of leaves amounts to 67 per cent. of the original leaves.

2. *Oleandra* (sp.). E. Indies. Leaves arranged in whorls of 5 each, two whorls placed close together, alternate, forming a complex or double whorl of 10 leaves. Each such pair of whorls placed about 2 or $2\frac{1}{4}$ inches distant from the whorls above and below it. Divergence $= \frac{1}{10}$.

3. *O. neriiformis.* Luzon. Leaves arranged in whorls of 6 each, placed two and two together, alternate, as in the preceding, and distant from those above and below them. Divergence $\frac{1}{12}$.

4. *O.* (sp.). Whorls of leaves in pairs, alternate, each whorl containing 5 leaves. Divergence $= \frac{1}{10}$.

5. *O.* (sp.). Khasya Hills. Whorls of leaves in pairs, alternate, each whorl containing 5 leaves. Divergence $= \frac{1}{10}$.

6. *O. Wallichii.* Nepaul and Assam. Whorls of leaves in pairs, alternate, 5 leaves in each whorl; the pairs of whorls are 3 inches apart. Divergence $= \frac{1}{10}$.

From the preceding facts we may infer that the whorled species of *Oleandra* are probably constructed on two types of whorls (5–6), both of which, by suppression of leaves, as already explained, may be reduced to the phyllotaxis of alternate-leaved plants.

7. *Aspidium Filix mas.* Britain. In this Fern the rootstock exhibits an arrangement of leaves and leaf-scars, alternate, 7–8 in each whorl, as is well shown in the 'Annals of Nat. History,' December 1859, Pl. X. fig. 9.

In the Ferns and Club-Mosses, the whorled arrangement of leaves, although following the usual law, appears to be insufficient to produce the division of the stem into nodes, as happens in the Equisetaceæ and some other natural families.

The next case to which I would direct attention is that of the *Casuarineæ,* represented by an old-fashioned genus, *Casuarina,* mostly confined to Australia and Tasmania, though it has some species in the East Indies and elsewhere. In this case, the whorled structure is perfect, as much so as in *Equisetum*, although it is an Exogen, and apparently of a high order. Whether this group survives, like other Australian forms, as the representative of lost groups, or is to be regarded as a new and well-developed type, the result of careful selection on the part of the goddess Nature, I leave for the consideration of those acquainted with the secrets of Creation.

IV. Casuarineæ.

1. *Casuarina Lehmanniana.* Tasmania. Leaves in whorls of 8, alternate. Divergence $= \frac{1}{16}$.

2. *C.* (sp.). Tasmania. Leaves in whorls of 6, alternate. Divergence $= \frac{1}{12}$.

3. *C.* (sp.). Australia. Leaves in whorls of 8, alternate. Divergence $= \frac{1}{16}$.

4. *C. Miguelii.* Tasmania. Leaves in whorls of 8, alternate. Divergence $= \frac{1}{16}$.

5. *C. Grumii.* Tasmania. Leaves in whorls of 10, alternate. Divergence $= \frac{1}{20}$.

6. *C. quadrivalvis.* Tasmania. Leaves in whorls of 10, alternate. Divergence $= \frac{1}{20}$.

7. *C. equisetifolia.* Canara, East Indies. Leaves in whorls of 8, alternate. Divergence $= \frac{1}{16}$.

8. *C.* (sp.). Swan River. Leaves in whorls of 4, alternate. Divergence $= \frac{1}{8}$.

9. *C. Preissiana.* Eliza Mountain, Freemantle. Leaves in whorls of 4, alternate. Divergence $= \frac{1}{8}$.

10. *C. muricata.* Leaves in whorls of 6, alternate. Main stems have leaf-scars of 7–8, alternate. Divergence $= \frac{1}{12}$.

11. *C.* (sp.). Feejee Islands. Leaves in whorls of 8, alternate. Divergence $= \frac{1}{16}$.

12. *C. nana.* Leaves of stem, smaller branches, and carpels of fruit cones, in whorls of 5, alternate. Divergence $= \frac{1}{10}$.

13. *C.* (sp.). Swan River. Whorls of stem and fruit, 7, alternate. Divergence $= \frac{1}{14}$.

14. *C.* (sp.). Philippine Islands. Whorls of stem and fruit, 7, alternate. Divergence $= \frac{1}{14}$.

15. *C. distyla.* Tasmania. Leaves in whorls of 7, alternate. Fruit carpels in whorls of 7, alternate. Divergence $= \frac{1}{14}$.

16. *C. obesa.* Near town of Perth, Swan River: a tree 35 feet high. Leaves in whorls of 12, alternate. Carpels in whorls of 12, alternate. Divergence $= \frac{1}{24}$.

17. *C.* (sp.). Swan River. Leaves in whorls of 7, alternate. Divergence $= \frac{1}{14}$.

18. *C.* (sp.). Swan River. Leaves in whorls of 5, alternate.

Fruit whorls 5, alternate, showing 10 vertical rows of opened carpels. Divergence = $\frac{1}{10}$.

19. *C.* (sp.). Swan River. Leaves in whorls of 6, alternate. Divergence = $\frac{1}{12}$.

20. *C.* (sp. with spinous, slightly twisted leaves). Swan River. Leaves in whorls of 4, alternate. Fruit whorls of 4, alternate, showing 8 vertical rows of carpels. Divergence = $\frac{1}{8}$.

21. *C.* (sp.). Swan River. Leaves in whorls of 9, alternate. Fruit whorls of 9, ditto. Divergence = $\frac{1}{18}$.

22. *C. Hugeliana* (35 feet high). Mount Brown, 900 feet. Leaves in whorls of 8, alternate. Divergence = $\frac{1}{16}$.

23. *C.* (sp.). West Australia, between Perth and King George's Sound. Leaves in whorls of 7, alternate. Fruit whorls ditto. Divergence = $\frac{1}{14}$.

24. *C.* (sp.). W. Australia. Leaves in whorls of 8, alternate. Fruit whorls ditto. Divergence = $\frac{1}{16}$.

25. *C. rigida.* Port Phillip. Leaves in whorls of 7, alternate. Divergence = $\frac{1}{14}$.

26. *C. cristata.* Avoca. Leaves in whorls of 12, alternate. Divergence = $\frac{1}{24}$.

27. *C. rigida.* Sealer's Cove. Leaves in whorls of 8, alternate. Divergence = $\frac{1}{16}$.

28. C. (sp.). Common "She Oak" of Cape Riche, forming a large tree. Cape Riche, West Australia. Leaves in whorls of 10, alternate. Fruit whorls ditto. Divergence = $\frac{1}{20}$.

29. *C.* (sp.). Cape Riche, W. Australia. Leaves in whorls of 9, alternate. Fruit whorls ditto.

30. *C.* (sp.). Vavau and Lifuka, Friendly Islands. Leaves in whorls of 7, alternate. Fruit whorls ditto. Divergence = $\frac{1}{14}$.

31. *C.* (sp.). Near Cape Riche, W. Australia. Leaves in whorls of 5, alternate. Fruit whorls ditto. Divergence = $\frac{1}{10}$.

32. *C.* (sp.). Between King George's Sound and Cape Riche. Leaves in whorls of 9, alternate. Divergence = $\frac{1}{18}$.

33. *C.* (sp.). Between King George's Sound and Cape Riche. Leaves in whorls of 5, alternate; leaf-scars on old stem and twigs very Lepidodendriform and quincuncial. Fruit whorls of 5, alternate. Divergence = $\frac{1}{10}$.

34. *C.* (sp.). Near Cape Riche, W. Australia. Leaves in whorls of 5, alternate. Leaf-scars of stem well marked. Fruit whorls of 5, alternate. Divergence = $\frac{1}{10}$.

On comparing the numbers of leaves in the whorls, it appears that they may all be reduced to the following—

4, 5, 6, 7, 8, 9, 10, 12,

the favourite numbers being 5, 7, and 8. The angles of divergence are denoted by the reciprocals of these numbers, doubled, as already explained. In fact, the perfect whorl must be considered as made up of two adjacent whorls, the leaves of which, being intermediate, give double the number, or only half the interval between each for the angle of divergence.

V. Proteaceæ.

A very remarkable group of Exogens, the Proteaceæ, possesses among its number many whorled species, which supply us with numbers additional to those of the Casuarineæ. In the family of Casuarineæ we found the number 5, which forms so important an element in the other Exogens; and in the Proteaceæ we meet with the number 3, which is only less important.

1. *Lambertia ericifolia.* Swan River. Leaves arranged in whorls of 3, alternate. Branches, flowers, and fruit follow the same law. Divergence $= \frac{1}{6}$.

As all the species of *Lambertia* which I have examined follow this law, it will be sufficient to give their names and localities:

2. *L. uniflora.* Swan River.
3. *L. multiflora.* Swan River.
4. *L. ilicifolia.* Swan River.
5. *L.* (sp.). Swan River.
6. *L.* (sp.). Near Cape Riche, W. Australia.
7. *L.* (sp.). Ditto.
8. *L.* (sp.). Ditto.
9. *L.* (sp.). King George's Sound.
10. *L.* (sp.). Sydney, New South Wales.
11. *L. inermis.* Between Perth and King George's Sound. Variety with yellow flowers.
12. *L.* (sp.). King George's Sound.
13. *L. formosa.* New South Wales.

(Divergence in all cases $= \frac{1}{6}$.)

14. *Brabejum* (sp.). Cape of Good Hope. Leaves in whorls of 6, alternate. Divergence $= \frac{1}{12}$.

15. *B.* (sp.) Cape of Good Hope. Leaves and branches in whorls of 8, alternate. Divergence $= \frac{1}{16}$.

16. *B. stellatum.* Cape of Good Hope. Three specimens examined, from different collections. In all of them I fonnd the number of leaves in the alternate whorls to be 7, giving thus a divergence of $\frac{1}{14}$.

VI. Ericaceæ.

In this large and important order of Exogens, the whorled law of arrangement universally prevails, the number of leaves in each whorl being

2, 3, 4, 6, and occasionally 7.

These whorls all conform to the law laid down, and give rise to diverging angles of

$$\frac{1}{4}, \frac{1}{6}, \frac{1}{8}, \frac{1}{12}, \frac{1}{14}.$$

In this natural order, 3 leaves in the whorl often occur, as also in the Proteaceæ : the other numbers of leaves in the whorls have been already met with ; and that of 2 in the whorl, or opposite-leaved plants, is universal through the whole group of Exogens.

VII. Cyclostigmaceæ.

The fossil plants of the Yellow Sandstone of the co. Kilkenny occur, as they do in other parts of Ireland, in the Sandstones lying immediately under the great mass of the Carboniferous Limestone, which constitutes the most important member of our Irish fossiliferous rocks.

They are found at Jerpoint, about a mile and a half south of the Abbey, on the roadside, near the Corn-mill on the road to Ballyhale, about 90 feet below the lowest bed of limestone, in rocks composed of red, white, and blue limestone with Tribo-liths formed of pink quartz rounded pebbles grooving the hone-stone; and above the plant-beds a remarkable white grit conglomerate is found. The plant-beds, on the same geological horizon, are also found in the railway cutting at Ballyhale.

They are found, however, in the greatest abundance, and in the best state of preservation, on the top of Kiltorcan Hill, near the railway station of Ballyhale. I believe the plant-beds on the summit of this hill to form an "outlier," and to occupy the same geological position with respect to the limestone as the beds at Jerpoint and those of the railway cutting.

The fossil plants here found have never been described, except casually: they consist of remains of a large Fern, called *Cyclopteris Hibernica* by Prof. Forbes, associated with a large bivalve, named by him *Anodon Jukesii*; of undescribed dermal plates of a cartilaginous fish, probably a species of *Coccosteus*; and of numerous unknown plants closely allied to *Lepidodendron*, and so named by Prof. Forbes and M. Brongniart, the latter of whom has named a remarkable species, preserved in the Museum of the Royal Dublin Society, *Lepidodendron Griffithii.* Others of these fossil plants have been named *Knorria*; and a large undescribed group remains, to which I propose to give the name *Cyclostigma.*

Cyclostigmaceæ.

A natural order of fossil plants, found in the lowest beds of the Carboniferous system, part of the oldest flora known to have existed on the globe. Probably closely allied to the orders described as *Knorria, Lepidodendron,* and *Sigillaria.* Known only by their leaf-scars and leaves, which were arranged in alternate whorls; plants not jointed at the whorls; the leaf-scars perfectly circular, showing in many cases a minute and well-marked dot in the centre, probably coinciding with a central bundle of woody tissue; many of the larger plants show traces of a thick central woody axis, like that found in *Stigmaria*; stems much crushed and flattened, as if they were not woody throughout.

They approach nearest to *Stigmariaceæ,* from which they differ in the leaf-whorls being further apart and more distinct.

There are many varieties of this remarkable fossil, showing the alternate whorled arrangement of leaf-scars. None of them are perfect stems, but appear to be torn portions of the rind of large plants which have been macerated by floating for a long time in water. In the quarry at Kiltorcan the *Cyclostigma* is found in layers different from those in which the *Cyclopteris Hibernica* occurs.

In some specimens of *Cyclostigma* the leaf-scars are closer together than in the last, and are somewhat oblique to the transverse line of the stem,—this obliquity being due to distortion caused by lateral pressure of the mudstone in which the fossils occur. The whorled arrangement of the leaves, each whorl being alternate to that above and below it, is frequently well shown.

Cyclostigma Kiltorkense.

Stem (flattened) $3\frac{1}{2}$ inches in diameter. Leaves in alternate whorls, 25 in each whorl; whorls 1 inch apart. Divergence $=\frac{1}{50}$. Central woody axis $\frac{6}{10}$ inch in diameter (flattened), shown by the strongly marked band in the centre of the stem.

This is the largest of the species of *Cyclostigma* found at Kiltorcan, and I have given its specific name from the locality.

Cyclostigma minutum.

Leaves in alternate whorls, the whorls being somewhat more distant from each other than the leaves; the centre of each leaf-scar marked by a well-defined minute dot. Branches of stem dichotomous.

This is the species figured in Sir Charles Lyell's 'Manual,' 5th edition, p. 418. It is a well-marked and easily-recognized fossil. It is also the same as the fossil figured by me in the Journal of Geol. Soc. Dublin, vol. vi. p. 235, and named *Lepidodendron minutum.* The latter was found at Tallow Bridge, co. Waterford.

Cyclostigma Griffithii.

Leaves in alternate whorls, 40 in each whorl; whorls less than $\frac{1}{2}$ inch apart. Divergence $= \frac{1}{80}$. Stem 2·2 inches in diameter (flattened). The leaves of the whorls are rendered oblique to the transverse axis by distortion; and where oblique, there are 6 leaf-intervals to the inch; but where they run across the stem in their natural position, there are 9 to the inch.

I have much pleasure in naming this species after Sir Richard Griffith, in whose Yellow Sandstone territory many specimens of it occur, and, by their general analogy to the Carboniferous *Lepidodendra*, vindicate the propriety of considering, as he has done, the sandstones and conglomerates among which they are found as the natural base of the Carboniferous system of Ireland.

XLVII.—*On the Occurrence of a Sucker-like Adhesive Apparatus in the* Daphniadæ *and allied Crustacea.* By Rudolph Leuckart*.

[With a Plate.]

During my residence at Nice in the spring of 1853, I observed a small Entomostracan of the group of the *Daphniadæ*, which, notwithstanding its similarity to *Polyphemus*, Müll., belonged, from the formation of its large antennæ and of its abdomen, to the genus *Evadne*, Lov. I regarded it as new, and called it *Evadne polyphemoïdes*. (Similar species, but differing in the number of joints in the large antennæ, have been described by Dana under the name of *Polyphemus brevicaudis*, and also by Liljeborg under that of *Podon intermedius*, Kröy.) The same animal has since been seen and investigated at Heligoland by Pagenstecher and myself.

The following characters may be given to distinguish my species. The legs gradually become shorter and more closely approximated posteriorly. Instead of the long and slender terminal setæ, the two middle legs bear two short and thick hooks with the inner margin plumose. The secondary appendage of the last pair of legs is almost obsolete. The lower vitreous cones of the enormous eye are separated from the rest by a space, and are considerably shorter than the preceding ones; the last of all are also of a different, pyriform shape.

What most tended to fix my attention on this little animal was an unmistakeable, large, round sucking-disk (Pl. XVI. B. fig. 8),

* Translated by W. S. Dallas, F.L.S., from Wiegmann's Archiv, 1859, p. 262.